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Progress Report for Grant NAG 5-2963

**Solar cycle dynamics of
solar, magnetospheric, and heliospheric particles,
and long-term atmospheric coupling:
SAMPEX**

Period: July 1, 1995 - July 1, 1996

**University of Maryland
Aerospace Corporation
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University of Colorado
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Langley Research Center
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July 1996

**Progress Report: Solar cycle dynamics of
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long-term atmospheric coupling: SAMPEX**

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Summary

This report summarizes science analysis activities by the SAMPEX mission science team during the period during the period July 1, 1995 through July 1, 1996. Bibliographic entries for 1995 and 1996 to date (July 1996) are included. The SAMPEX science team was extremely active, with 20 articles published or submitted to refereed journals, 18 papers published in their entirety in Conference Proceedings, and 53 contributed papers, seminars, and miscellaneous presentations. The bibliography at the end of this report constitutes the primary description of the research activity. Science highlights are given under the major activity headings, as well as other activities of the team.

Scientific Investigations

a) Anomalous Cosmic Rays

Analysis of the anomalous component of cosmic rays (ACRs) continued to be a major focus of activity. The primary results presented during 1995/6 were:

- Definitive measurement of the ionization state of ACR oxygen, reported in *Astrophys. J. Letters*, confirmed that these particles are interstellar material ionized within the heliosphere and accelerated in the outer heliosphere.
- Comprehensive analysis of ACR gradient studies throughout the heliosphere, showing that the gradients during the current solar minimum had changed sign from the previous minimum (1986), giving evidence for the importance of drift processes in the heliosphere
- Discovery of multiply charged ACR oxygen in the energy range above ~20 MeV/nucleon, showed that the ACR acceleration mechanism depended on the ionization state of the ions, operated in the outer heliosphere, and had an acceleration time scale of approximately 1 year.
- Study of the isotopic composition of ACRs continued, with improved statistics. Within the statistical accuracy of these measurements the ACR composition is consistent with that of standard solar system abundances.
- The trapped ACR pinpointed by SAMPEX were studied in detail with MAST and PET. Flux levels were determined as well as comparisons with models for trapping this component. While some discrepancies remain, there was general agreement between the observed flux levels and spectra, and models for the origin of these particles through stripping of ACRs of most or all of their remaining orbital electrons through grazing collisions in the upper atmosphere.

b) Solar Energetic Particles

Solar energetic particle (SEP) charge states were studied using the LICA, HILT, and MAST sensors, with reports generated independently for each of them. These studies concentrated on the October/November 1992 solar particle events, which were the only ones so far during the mission that generated fluxes high enough to be used for comprehensive charge state measurement by HILT and MAST. The primary results were:

- at low energies, LICA found charge states consistent with coronal temperatures of 1-2 million °K, and also consistent with earlier studies except for Fe, which has a significantly lower charge (11.04 ± 0.22) than that reported in an earlier survey by Luhn (14.09 ± 0.09).
- MAST reported the first comprehensive measurement of SEP charge states, in the range ~10-80 MeV/nucleon, and found results consistent with earlier studies, and with LICA except that the Fe charge state measured by MAST was near 14-15.
- HILT covered the range intermediate to LICA and MAST, and its charge state measurements showed a transition of Fe charge state from the lower values at LICA energies to the higher ones found by MAST, indicating an energy dependence of the ionization state.
- In work on impulsive, ^3He -rich solar particle events, LICA and HILT data were used to study spectral forms with unprecedented accuracy. The instruments observed spectra in these events extending to 10 MeV/nucleon and beyond, thus constraining models for acceleration in these flares. Earlier instruments had been unable to observe such spectra since these are low intensity events, and prior instrumentation was not as sensitive as LICA and HILT.

c) Magnetospheric Precipitating Electrons

Several studies were carried out concerning precipitating electrons:

- "Microbursts" of relativistic electron precipitation were observed on HILT, in narrow, persistent latitudinal bands near the outer ends of the radiation belt. The bursts lasted 10-30 sec, and developed and decayed in time scales of a few hours. These microbursts may be due to wave-particle interaction involving a relaxation-oscillator type of mechanism. They show that the outer-zone electron precipitation frequently results from a strong scattering process, and not by weak diffusion of stably trapped electrons into the drift loss cone.
- Long term studies of electron precipitation observed by LICA and PET were used to compare with NO measurements made by the HALOE experiment on UARS. Cases were presented with significant NO increased from 70-120 km associated with the occurrence of enhanced electron populations in the outer trapping regions of the magnetosphere.
- A detailed 2-D model simulation of the downward transport of NOy into the stratosphere was carried out to assess the importance of the NOy production on atmospheric ozone. The model calculations showed a significant linkage, and these results were consistent with the ATMOS NOy observations during November 1995.

d) Trapped H and He Isotopes

- Energetic hydrogen isotopes trapped in the inner zone were studied with PET, in order to characterize the fluxes and compare with model calculations for production of the deuterium isotope through collisions with atmospheric nuclei.

Data Analysis Activities

Data analysis at UMSOC was routine, with Level-1 MDFs sent out to the investigator team approximately 2-3 weeks after receipt.

NSSDC Submission

A large team effort went into the development of software for creation of calibrated flux files for 30s averages, and polar cap average data for NSSDC. The data submission to NSSDC is in the form of "flatfiles", which contain 24 hours of 30s data, or else 1 month of polar cap average data. Submission to NSSDC is being carried out by FTP to a computer at NSSDC.

NSSDC personnel have generated the requisite tables to convert the flatfiles into CDF.

Solar Geophysical Data Bulletin Submissions

SAMPEX Interplanetary Particle Fluxes for the period Jan-Jun 1995 appeared in the April 1996 (#620) issue of Solar-Geophysical Data (SGD) Comprehensive Reports. A summary of the submissions to date is below.

Dates of data	SGD vol.	SGD issue date
Jul-Dec 1992	#595	March 1994
Jan-Jun 1993	#596	April 1994 - revised in issue #606
Jan-Dec 1993	#606	February 1995
Jan-Dec 1994	#618	February 1996
Jan-Jun 1995	#620	April 1996

World Wide Web site

The SAMPEX WWW site (<http://lepsam.gsfc.nasa.gov/www/sampex.html>) had over 2300 accesses by non-team members over a several month period. Almost 500 of these were from Europe and Canada. The page was expanded to include the following sub-sections:

SAMPEX SPACECRAFT

- Description of the spacecraft, its subsystems and orbit.

SAMPEX INSTRUMENTS

- Instrument descriptions, their science objectives and full publications.

SAMPEX SCIENCE TOPICS

- Examples of scientific investigations together with data and images and list of SAMPEX discoveries.

SAMPEX INSTITUTIONS AND PEOPLE

- People and institutions comprising the SAMPEX collaboration.

SAMPEX PUBLIC INFO & DATA

- Science data in the form of plots and images.

THE COOPERATIVE SATELLITE LEARNING PROJECT

- A joint project between government, industry, and the public education system to capture and channel students towards science and engineering curriculum and careers in the space industry.

SAMPEX INTERNAL MEMOS

Team Meetings

Team meetings were held to exchange results, coordinate current and future analysis projects, and plan future spacecraft/instrument operations.

SAMPEX Science Team Meeting #12

Monday, May 29, 1995

Room: Harbor #1B (rooftop level)

Holiday Inn Inner Harbor

301 W. Lombard St

Baltimore, MD 21201

SAMPEX Science Team Meeting #13

Monday-Tuesday, February 5-6, 1996

114 East Bridge Hall

Caltech, Pasadena CA

Spacecraft & Instrument Health and Operations

The SAMPEX spacecraft and instruments remained in excellent operating condition. Highlights during the period were:

HILT isobutane operation ceased on November 15, 1995, when the temperature of the pressure regulator was rising out of its normal range due to exhaustion of the tank. HILT was switched over to high energy mode operation March 4, 1996 18:02:58.

An experiment to obtain greater pitch angle coverage by spinning the spacecraft at 1 RPM about the "y" axis (sun-pointing) was carried out on February 1, 1996. Further tests were done on February 13-14, and March 5-8. After analyzing the results of these tests, the science team decided to go into 1 RPM spin mode for a several month run, and the spacecraft spinning commenced on May 8, 1996. Later in 1996 the team will reappraise the operations in this mode.

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